ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫНЫҢ
Қ. И. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті

Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Казахский национальный исследовательский
технический университет им. К. И. Сатпаева

N E W S

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
Kazakh national research technical university
named after K. I. Satpayev

SERIES
OF GEOLOGY AND TECHNICAL SCIENCES

4 (436)

JULY – AUGUST 2019

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

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«ҚР ҰҒА Хабарлары. Геология мен техникалық ғылымдар сериясы».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Меншіктенуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).
Қазақстан республикасының Мәдениет пен ақпарат министрлігінің Ақпарат және мұрағат комитетінде 30.04.2010 ж. берілген **№10892-Ж** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Мерзімділігі: жылына 6 рет.
Тиражы: 300 дана.

Редакцияның мекенжайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., 220, тел.: 272-13-19, 272-13-18,
http://www.geolog-technical.kz/index.php/en/

Редакцияның мекенжайы: Қазақстан, 050010, Алматы қ., Қабанбай батыра көш., 69а.
Қ. И. Сәтбаев атындағы геология ғылымдар институты, 334 бөлме. Тел.: 291-59-38.

Типографияның мекенжайы: «Аруна» ЖК, Алматы қ., Муратбаева көш., 75.

«Известия НАН РК. Серия геологии и технических наук».
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан (г. Алматы)

Свидетельство о постановке на учет периодического печатного издания в Комитете информации и архивов Министерства культуры и информации Республики Казахстан **№10892-Ж,** выданное 30.04.2010 г.

Периодичность: 6 раз в год
Тираж: 300 экземпляров

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, ком. 219, 220, тел.: 272-13-19, 272-13-18,
http://nauka-nanrk.kz /geology-technical.kz

Адрес редакции: Казахстан, 050010, г. Алматы, ул. Кабанбай батыра, 69а.
Институт геологических наук им. К. И. Сатпаева, комната 334. Тел.: 291-59-38.

Адрес типографии: ИП «Аруна», г. Алматы, ул. Муратбаева, 75

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.
ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)
Owner: RPA "National Academy of Sciences of the Republic of Kazakhstan" (Almaty)
The certificate of registration of a periodic printed publication in the Committee of information and archives of the Ministry of culture and information of the Republic of Kazakhstan N 10892-Ж, issued 30.04.2010

Periodicity: 6 times a year
Circulation: 300 copies

Editorial address: 28, Shevchenko str., of. 219, 220, Almaty, 050010, tel. 272-13-19, 272-13-18,
http://nauka-nanrk.kz/geology-technical.kz

Editorial address: Institute of Geological Sciences named after K.I. Satpayev
69a, Kabanbai batyr str., of. 334, Almaty, 050010, Kazakhstan, tel.: 291-59-38.

Address of printing house: ST "Aruna", 75, Muratbayev str, Almaty

N E W S
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN
SERIES OF GEOLOGY AND TECHNICAL SCIENCES
ISSN 2224-5278
Volume 4, Number 436 (2019), 145 – 150 **https://doi.org/10.32014/2019.2518-170X.108**

UDC 622.831.322

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WAVE PROPERTIES OF COAL-BEARING STRATA

Abstract. The study was performed in the coal mines of Karaganda coal basin located under the safety pillars and stratum edges. The study comprised of measurements of dimensions of mines located under the safety pillars and edges of above coal strata. The results showed that in all investigated mines the height of mine located under the safety pillar (edge of stratum) varied in a wave pattern. The article summarise the comparative analysis of investigation with the theory predicted laws of wave processes. In the result of the analysis the diffraction features of abutment pressure and the regularities of its propagation under the safety pillars and stratum edges were revealed.

Key words: bearing pressure, the pillar of coal, marginal part of the coal seam, the zone of high rock pressure, interference, diffraction, harmonic process.

Introduction. The actual rock is a multicomponent media formed under the influence of many geological factors. Mechanical features of different rock types vary widely. The processes developed in the rock adjacent to mines and excavations are materially influenced by the stress caused by mining activities and their own mechanical features. It is virtually impossible to take into account all the range of mechanical features of natural soil, and due to that various mechanical models of rock are adopted. These models account for the major substantial features of rock while ignoring minor features. Such substantial features are elasticity, plasticity, frangibility, solidity, isotropism and uniformity of rock. «The real world is so rich in its variety that when we try to invent a model as close to reality as possible we soon are lost in the chase for the most complicated equations consisting of unknown variables following unknown laws. Should we determine these equations they develop in even more complicated ones, ad infinite" - says R. Bellman [1]. The study of the majority of natural phenomena in view of the cause and effect laws is often overwhelmingly complicated, if possible.

Nowadays the problem of finding the laws of organization of physical systems is clearly interdisciplinary; it doe not belong to physics, biology, ecology or linguistics itself. The science in the whole range of problems it addresses has come close to understanding of the ways of solution of this problem. It is proven by the existence of a wide variety of science disciplines aimed at finding the laws of organizations of physical systems, though that fact may be hidden beyond apparent variety of theories: dissipative structures, generalized catastrophe, off-balance phase state and bifurcations, irreversible process and structural stability, autowave process and synergetics [2].

Material and methods. Synergetics as a science field is of integrative nature. It combines physics, chemistry, biology, psychology, social studies, astronomy, philosophy and others stating by identification of the laws all of them share. It is an interdisciplinary science, which provides strictly mathematical substantiation of self-organization processes, occurring in open complex nonlinear systems Synergetics deals with the study of systems comprising of subsystems of various nature. It considers how the interaction of such subsystems leads to the emergence of spatial, temporal and spatial-temporal structures on a macroscopic scale. Thermodynamics of non-equilibrium processes, the theory of random processes, the theory of non-linear oscillations and waves are basis of synergetics.

The world as a whole and every structure of it is a Wave. In other words, not just microscopic objects (traditionally studied in quantum theory), but also each existing thing, all the diversity of the systems of the world, as soon as they are dialectically contradictory, represent the Wave which is a structural resonance of the substrate they're made of, i.e. sort of "interference" of opposites within unity. Physical interference fringe pattern, whether arising as a result of superposition of coherent light, sound or surface waves is just a particular case of the most common resonating principle of the nature, which manifests in interference.

Sources [3, 4] are the studies of wave nature of abutment pressure under safety pillars and stratum edges of coal layers, where the wave nature of distribution of stationary abutment pressure is found. Any wave propagation generates interference and diffraction, so it makes perfect scene to verify the correspondence of wave processes observed in carbonaceous rock to the common oscillatory laws. For instance, diffraction in optics is used to confirm the wave structure of light. Diffraction is defined as the set of facts which are determined by wave nature of light and observed during the propagation of light in a strongly pronounced nonlinear media. It narrower sense it is defined as the bending of waves around the corners of an obstacle or aperture into the region of geometrical shadow of the obstacle. Diffraction is the feature of propagation of waves [5].

Results and discussion. As for the carbonaceous rock the diffraction of rock pressure waves shall take place at the border of the two diverse media: undisturbed rock (elastic medium) and excavated space (nonelastic medium). This is why the coal safety pillar may be considered as a waveguide through which the wave of elastic abutment pressure propagate.

The type of diffraction pattern depends on the value of wave parameter P [6]:

$$P = \frac{\sqrt{\lambda \cdot L}}{a}$$

where a – width of the waveguide, meters; L – the distance from the plane of the waveguide to the observations plane parallel to it, m; λ – wavelength , m.

The excavated space is an obstacle to propagation of such abutment pressure waves, being a kind of screen for such waves. Thus, in relation to rock pressure: a – width of safety pillar $B_ц$, m; L – thickness of inter-stratum space $h_м$, m; λ – abutment pressure wavelength, equal to the doubled thickness of top rock $2h_{о.к.}$ [4], m. Then the wave parameter equation is:

$$P = \sqrt{\frac{2h_{ок} \cdot h_м}{B_ц}}$$

$$P = \frac{\sqrt{2h_{ок} \cdot h_м}}{B_ц}$$

At P 1 (wide slot) the intensity distribution on the plane is shown on figure 1. Adjacent to points T_1 и T_2, located across the edges of the slot it resembles the intensity distribution adjacent to point T_0, at diffraction on the edge of semi-infinite obstacle (figure 2). The amplitude in point T_0, located across the edge of the screen is twice less than without the obstacle. The intensity of light is 4 times less, correspondingly. The intensity J of elastic wave is the amount of energy transferred by the wave per unit of time through unit of space perpendicular to direction of propagation [9]. The intensity os sinusoidal wave is proportional to its amplitude squared. With regards to rock pressure waves the amplitude corresponds to the decrease of mine height h subject to pressure.

Lets compare the diffraction pattern on the edge of semi-infinite obstacle (figure 2) and the diffraction pattern of rock pressure on the edge of coal stratum obtained during studies [7] (figures 3 and 4). The study comprised of measurements of dimensions of mines located under the safety pillars and edges of coal strata.

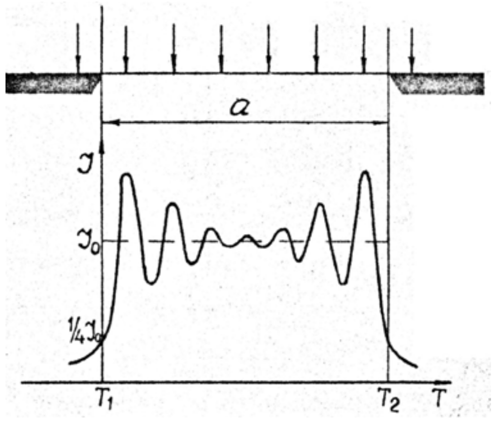

Figure 1 – The intensity distribution of light diffraction on the wide slot at *P* 1

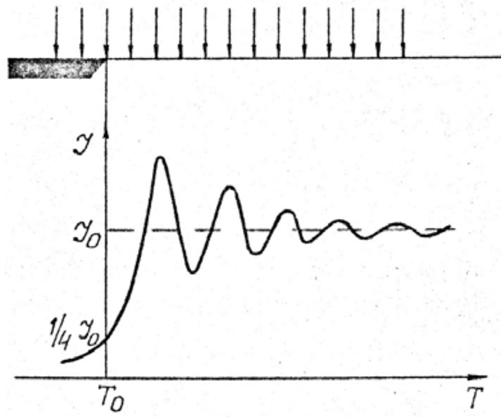

Figure 2 – The intensity distribution of light diffraction on the edge of semi infinite obstacle

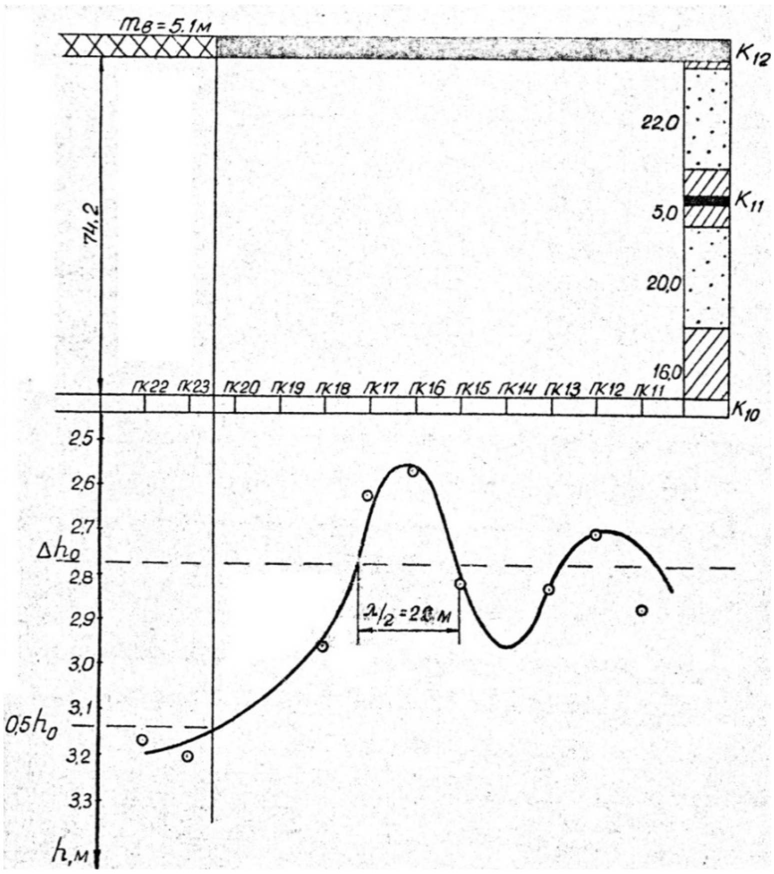

Figure 3 – Observed abutment pressure in the belt entry 42K $_{10}$-3

The visual resemblance of diffraction patterns is further confirmed by absolute values of deformations of excavations. Thus in the belt entry $42K_{10}$ –3 having original height h = 3,5 m, the axis of abutment pressure wave is located at h_0 = 2,77 m, i.e. deformation is Δh_0 = 3,5 – 2,77 = 0,73 m, and the deformation in the point located under the edge of stratum, Δh_1 = 3,5 – 3,12 = 0,37 m. So, $\Delta h_1/\Delta h_0$ = 0,51, i.e. the amplitude in the point located contrary to the edge of the obstacle is twice less than without the obstacle (factoring measurement error). The same applies to the belt entry $45K_{10}$ – 3. Given the original height of excavation h = 3,635 m the axis of abutment pressure is located at h_0 = 3,15 m, i.e.. Δh_0 = 0,485 m, Δh_1 = 0,245 m, $\Delta h_1/\Delta h_0$ = 0,5.

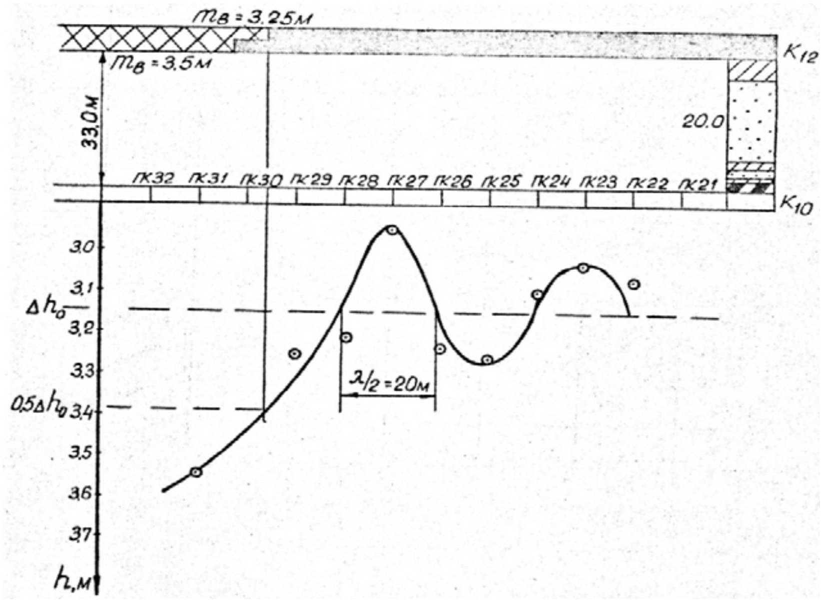

Figure 4 – Observed abutment pressure in belt entry 45K $_{10}$–3

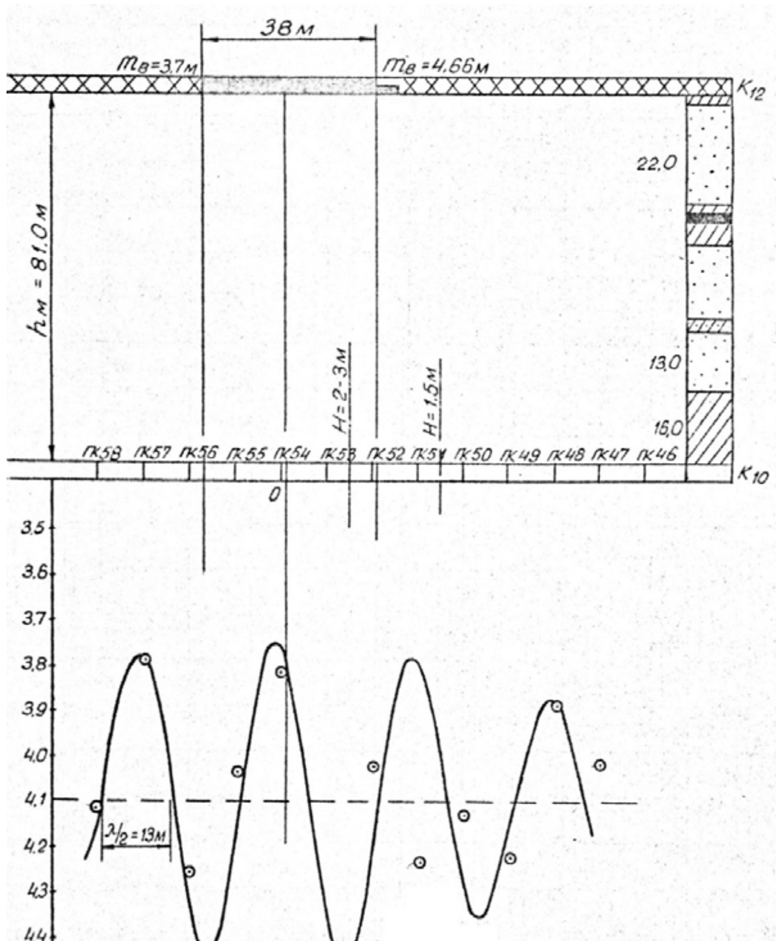

Figure 5 – Observed abutment pressure in the airway 42K_{10}–3

At *P* 1 the oscillations of intensity spread all over the $T_1 - T_2$, which corresponds to the image of the slot in geometrical optics, and is also observed in the area of geometrical shadow (contrary to monotonous decrease adjacent to the edges of the shadow at *P* 1. Depending on the values of *P* in the middle of diffraction pattern the point O may be either minimum or maximum intensity. When there is an odd number of half wave lengths for point O $(2k + 1)\ \lambda/2$, the amplitude in point O is less than in the absence of the obstacle. When there is an even number of half wave lengths $(2k)\ \lambda/2$ – the amplitude in point O is less than in the absence of the obstacle. Refer to figure 5 – the abutment pressure in airway 42K $_{10}$-3 for example. Here, given that wave parameter P=1.6, oscillation of abutment pressure are also observed in the geometrical shadow area, though diffraction pattern is distorted by small-scale fluctuations. If the safety pillar is 38 m wide and half wavelength is 13 m, three half-waves fit and, consequently, the amplitude in the center of diffraction pattern O is higher than without the pillar.

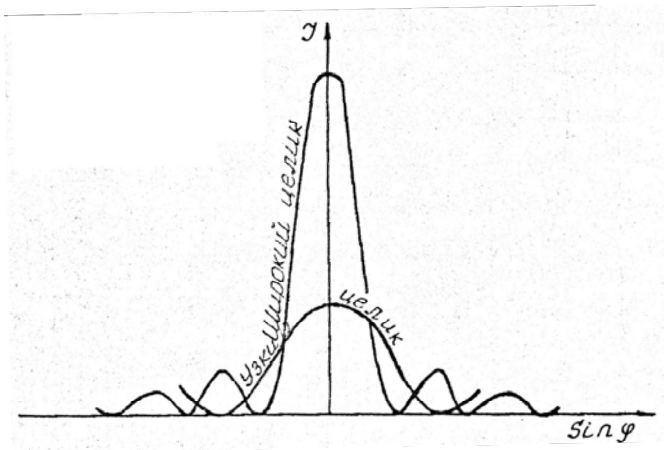

Figure 6 – Diffraction of abutment pressure waves at P >> 1

If *P* >> 1, the diffraction pattern is similar to that of Fraunhofer diffraction on the same slot (figure 6). The main maximum lies opposite the slot, and is the wider the narrower the slot is. The distance from the center of diffraction pattern to the firs maximum increases with the increase of safety pillar width $B_ц$. At this, the central peak gets wider and lower. The intensity decreases going from the center to edges of the plane of observation.

Angle φ between the original direction of the wave and resulting direction is called the diffraction angle. The energy of original wave distributes unevenly in angular space. It is lower at higher diffraction angles.

Conclusions. Thus, the observation of diffraction of abutment pressure waves and their correspondence to common laws of wave propagation confirms its wave nature.

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КӨМІР ҚҰРАМДЫ ҚАЛЫҢДЫҚТАРДЫҢ ТОЛҚЫНДЫ ҚАСИЕТТЕРІ

Аннотация. Көмір пластарының жиек бөліктерінде және тіреу астарында орналасқан Қарағанды көмір бассейні көмір шахтасының жер асты өңдеулерінде зерттеулер жүргізілді. Жоғары жатқан көмір пластарының жиек бөліктері мен тіреу астарындағы аймақтарда зерттеу тау-кен өңдеулерін өлшеу арқылы жүргізілді. Жүргізілген зерттеулер нәтижелері көрсеткендей, яғни тіреу астында орналасқан барлық қаралған өңдеулер аймақтарының ұзындығы толқынға ұқсас өзгеріп отырады. Бұл мақалада толқынды үрдістердің таралуының теориялық жағынан қаралған салыстырмалы талдаулардың нәтижелері келтірілді. Жүргізілген талдаулар

нәтижесінде қолдау қысымы мен көмір пластарының жиек бөліктері мен тіреу астарындағы таралу заңдылығының дифракционды қасиеттері анықталды.

Түйін сөздер: қолдау қысымы, көмір тіреулері, көмір пластарының жиек бөліктері, тау-кен қысымының жоғарғы шекарасы, интерференция, дифракция, гармоникалық үрдіс.

Р. Р. Ходжаев[1], Р. И. Габайдуллин[1], С. Н. Лис[2], Ш. К. Шапалов[3], Н. Н. Акимбекова[4], Г. К. Ивахнюк[5]

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ВОЛНОВЫЕ СВОЙСТВА УГЛЕНОСНОЙ ТОЛЩИ

Аннотация. Проведены исследования в подземных выработках угольных шахт Карагандинского угольного бассейна, расположенных под целиками и краевыми частями угольных пластов. Исследования проводились путём измерения размеров горных выработок на участках расположенных под целиками и краевыми частями вышележащих угольных пластов. Результаты проведенных исследований показали, что во всех выработках, в которых проводились наблюдения, высота участка выработки, расположенного под целиком (краевой частью) изменяется волнообразно. В статье приводятся результаты сравнительного анализа проведенных наблюдений с теоретическими положениями распространения волновых процессов. В результате проведенного анализа выявлены дифракционные свойства опорного давления и закономерности его распространения под целиками и краевыми частями угольных пластов.

Ключевые слова: опорное давление, целик угля, краевая часть угольного пласта, зона повышенного горного давления, интерференция, дифракция, гармонический процесс.

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www:nauka-nanrk.kz

ISSN 2518-170X (Online), ISSN 2224-5278 (Print)

http://www.geolog-technical.kz/index.php/en/

Верстка *Д. Н. Калкабековой*

Подписано в печать 22.07.2019.
Формат 70x881/8. Бумага офсетная. Печать – ризограф.
15,7 п.л. Тираж 300. Заказ 4.

Национальная академия наук РК
050010, Алматы, ул. Шевченко 28, т. 272-13-19, 272-13-18